NASA-CR-195157

/N TERIM

/N-46-CR

5 CIT.

11764

P. 6

Semi-Annual Report on NASA Grant NAGW5-1097:

Modeling of the Magnetosphere-Ionosphere-Atmosphere System.

1 November 1993 to 30 April 1994

During the period covered by this report we continued to investigate basic processes in magnetosphere-ionosphere coupling and to develop algorithms for analyzing ultraviolet, visible, and X-ray images that will be acquired on the POLAR spacecraft. The outline of the image analysis procedure has been described in the paper entitled 'Modeling of the Atmosphere-Magnetosphere-Ionosphere System (MAMI)' which is accepted for publication in a special GGS-ISTP issue of Space Science Review. This analysis combines several numerical models to obtain a self-consistent picture of the ionosphere and thermosphere.

Our ionosphere-aurora model was extended by the inclusion of the magnetic mirror force and a self-consistent parallel electric field in the ionosphere. These improvements resulted from Q.-L. Min's PhD thesis entitled 'A Self-Consistent Time Varying Auroral Model'. This work is now also published in the Journal of Geophysical Research (the title page of the thesis and the abstract of the publication are appended).

The electron transport model which forms a critical part of the aurora model was evaluated by comparison with laboratory measurements and auroral observations. We determined the uncertainties that arise from our limited knowledge of cross sections and energy degradation functions for electron neutral interaction. This work was submitted to Annales Geophysicae and is now accepted for publication. The results of this evaluation were also presented at the fall AGU meeting in San Francisco, December 1993. The abstracts of the paper and AGU presentation are appended.

(NASA-CR-195157) MODELING OF THE MAGNETOSPHERE-IONOSPHERE-ATMOSPHERE SYSTEM Ph.D. Thesis Semiannual Report, 1 Nov. 1993 - 30 Apr. 1994 (Alaska Univ.) 6 p

N94-35244

Unclas

G3/46 0011764

N15

A SELF-CONSISTENT TIME VARYING AURORAL MODEL

A

THESIS

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

By

Qilong Min, B.S., M.S.

Fairbanks, Alaska

September 1993

ABSTRACT

A time dependent model of auroral processes has been developed by self-consistently solving the electron transport equation, the ion continuity equations and the electron and ion energy equations. It is used to study the response of ionospheric and atmospheric properties in regions subjected to electron bombardment. The time history of precipitation events is computed for a variety of electron spectral energy distributions and flux magnitudes. Examples of daytime and night-time aurorae are presented. Precipitating energetic auroral electrons heat the ambient electrons and ions as well as enhancing the ionization rate which increases the ion concentration. The consequences of electric field acceleration and an inhomogeneous magnetic field in auroral electron transport in the topside ionosphere are investigated. Substantial perturbations of the low energy portion of the electron flux are produced: An upward directed electric field accelerates the downward directed flux of low energy secondary electrons and decelerates the upward directed component. Above about 400 km the inhomogeneous magnetic field produces anisotropies in the angular distribution of the electron flux. The effects of the perturbed energy distributions on auroral spectral emission features and on the electron temperature are noted. The response of the Hall and Pederson conductivities to auroral electron precipitation is discussed as a function of the characteristic energy of the spectral distribution.

N15

Evaluation of Uncertainties in Auroral Electron Transport Calculations

D Lummerzheim (University of Alaska, Fairbanks, Fairbanks, AK 99775-0800; 907-474-7564)
J Lilensten (CNRS, Grenoble, France)

Auroral electron transport calculations are a critical part of auroral models. We evaluate a numerical solution to the transport and energy degradation problem. The numerical solution is verified by reproducing simplified problems to which analytic solutions exist, internal self-consistency tests, comparison with laboratory experiments of electron beams penetrating a collision chamber, and by comparison with auroral observations, particularly the emission ratio of the N_2 second positive to N_2^+ first negative emissions. Our numerical solutions agree with range measurements in collision chambers. The calculated $N_2$2P to N_2^+1N emission ratio is independent of the spectral characteristics of the incident electrons, and agrees with the observed value reported in the literature. Using different sets of energy loss cross sections and different functions to describe the energy distribution of secondary electrons that emerge from ionization collisions, we find that based on the uncertainties of these input parameters, solutions to the electron transport equation have uncertainties of 15-20%.

1. 1993 Fall Meeting
2. 001610187
3. (a) D Lummerzheim
   Geophysical Institute
   University of Alaska
   Fairbanks, AK 99775-0800
   (b) 907-474-7564
   (c) 907-474-7290
4. SA
5. (a)
   (b) 0310 Airglow & aurora
   (c)
6.
7. 0%
8. Check enclosed
9. C
10.
11. No

N/S

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 98, NO. A11, PAGES 19,223–19,234, NOVEMBER 1, 1993

Effects of a Parallel Electric Field and the Geomagnetic Field in the Topside Ionosphere on Auroral and Photoelectron Energy Distributions

Q.-L. MIN, D. LUMMERZHEIM, M. H. REES, AND K. STAMNES

Geophysical Institute and Physics Department, University of Alaska, Fairbanks

The consequences of electric field acceleration and an inhomogeneous magnetic field on auroral electron energy distributions in the topside ionosphere are investigated. The one-dimensional, steady state electron transport equation includes elastic and inelastic collisions, an inhomogeneous magnetic field, and a field-aligned electric field. The case of a self-consistent polarization electric field is considered first. The self-consistent field is derived by solving the continuity equation for all ions of importance, including diffusion of O^+ and H^+, and the electron and ion energy equations to derive the electron and ion temperatures. The system of coupled electron transport, continuity, and energy equations is solved numerically. Recognizing observations of parallel electric fields of larger magnitude than the baseline case of the polarization field, the effect of two model fields on the electron distribution function is investigated. In one case the field is increased from the polarization field magnitude at 300 km to a maximum at the upper boundary of 800 km, and in another case a uniform field is added to the polarization field. Substantial perturbations of the low energy portion of the electron flux are produced: an upward directed electric field accelerates the downward directed flux of low-energy secondary electrons and decelerates the upward directed component. Above about 400 km the inhomogeneous magnetic field produces anisotropies in the angular distribution of the electron flux. The effects of the perturbed energy distributions on auroral spectral emission features are noted.

N15

Modeling of the Atmosphere-Magnetosphere-Ionosphere System MAMI

M.H. Rees and D. Lummerzheim, Geophysical Institute, University of Alaska, Fairbanks, AK 99775

R.G. Roble, High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO 80303*

ABSTRACT

The effects on the terrestrial atmosphere and ionosphere of energy and momentum sources of magnetospheric origin are investigated theoretically. Parameters measured by instruments on board the GGS spacecraft and by the GGS ground-based networks are used as inputs to the models that quantify the magnetosphere-ionosphere-thermosphere coupling. Images of the aurora acquired at ultraviolet, visible and x-ray wavelengths by instruments on board the POLAR spacecraft are particularly useful in this investigation by yielding good spatial coverage and high time resolution of the aurora.

N/S

Electron Transport and Energy Degradation in the Ionosphere: Evaluation of the Numerical Solution, Comparison with Laboratory Experiments and Auroral Observations

D. Lummerzheim[1] and J. Lilensten[2]

[1] *Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800, USA*

[2] *CEPHAG ENSIEG, BP 46, F-38402 St Martin d'Hères Cedex, France*

Submitted to Annales Geophysicae

Abstract

Auroral electron transport calculations are a critical part of auroral models. We evaluate a numerical solution to the transport and energy degradation problem. The numerical solution is verified by reproducing simplified problems to which analytic solutions exist, internal self-consistency tests, comparison with laboratory experiments of electron beams penetrating a collision chamber, and by comparison with auroral observations, particularly the emission ratio of the N_2 second positive to N_2^+ first negative emissions. Our numerical solutions agree with range measurements in collision chambers. The calculated $N_2$2P to N_2^+1N emission ratio is independent of the spectral characteristics of the incident electrons, and agrees with the value observed in aurora. Using different sets of energy loss cross sections and different functions to describe the energy distribution of secondary electrons that emerge from ionization collisions, we discuss the uncertainties of the solutions to the electron transport equation resulting from the uncertainties of these input parameters.